THE ANNALS

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[SIXTH SERIES.]

"................ per litora spargite muscum,
Naiades, et circùm vitreos considite fontes:
Pollice virgineo teneros hìc carpite flores:
Floribus et pictum, divæ, replete canistrum.
At vos, o Nymphæ Craterides, ite sub undas;
Ite, recurvato variata corallia trunco
Vellite muscosis e rupibus, et mihi conchas
Ferte, Deæ pelagi, et pingui conchylia succo."
N. Parthenii Giannettasii Ecl. 1.

No. 25. JANUARY 1890.

I.—*Some Remarks on the Anatomy of* Stephanoceros Eichhornii. By RUPERT VALLENTIN.

[Plates I. & II.]

NOTWITHSTANDING the fact that this Rotifer has been known to exist for nearly one hundred and thirty years, forming as it unquestionably does one of the most interesting objects for microscopical exhibition, still much remains to be learnt concerning its anatomy.

Having recently secured some very large specimens, I naturally consulted the last monograph (1) * with which I am acquainted, and was astonished to find how great were the differences of opinion concerning the most fundamental points of its anatomy. It then occurred to me to try if some of these points could not be determined by means of serial sections, since all other means had failed; and my results, although good, still leave considerable room for improvement.

I assume on the part of the reader a slight acquaintance with the anatomy of the animal, such as may be obtained from any text-book, and so will proceed to discuss those results which my work has so far yielded.

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* The numbers refer to Bibliographical List at end.

The Tube.—The tube or case in which the animal usually dwells consists of a jelly-like material, extending from the collar to the extremity of the foot. Into this, when the necessity arises, the animal can retire. It is formed by the young Rotifer soon after its exit from the parent's tube; but whence it originates has hitherto escaped observation. Mr. Jackson (2) says "Some few Rotifera develop round themselves a gelatinous case, which they inhabit permanently (*Floscularia*) or temporarily (*Philodina*), the origin of which is unknown." Dr. Hudson (*loc. cit.*) says, "Neither salivary, gastric, nor foot-glands have been observed in *Stephanoceros*; but, as the animal secretes a large and comparatively solid tube, it is clear it must have some organ for this purpose or that the substance of which the tube is constructed oozes from the surface of the body." The most important observer is Mr. Gosse (*loc. cit.*). He says, "A specimen, which was hatched under my eye, swam for ten minutes, and then became permanently attached to the upper glass of the box, so that it was vertical in position, with the foot next the eye, a favourable aspect for observing the development of the case. It presently began to dilate its body, and, in about five minutes from its attachment, I perceived a distinct filmy ring round it, perfectly circular, whose diameter was about twice that of the body. The little animal now began to lean over to one side, and the ring soon had another segment additional, leaning in the same direction. The case, for such it was, looked like two broad hoops of glass, each swollen in the middle and set one on the other, but not quite concentrically, at least to the eye of the observer. It was manifest that it was produced from an excretion from the body, owing its form and size to the animal's moving round on the foot as on a pivot."

It has been a fact familiar for many years to zoologists that many of the migratory Rotifera possess in the foot glandular bodies, the secretion from which enabled them to fix themselves for a long or short period to any substance.

Dr. Zacharias (3), in his paper on *Rotifer vulgaris*, says, "We know that they [pedal glands] are the seat of a secretory activity, and secrete a sticky product which serves to attach the animal to smooth surfaces."

Eckstein (4) gives a description of glands in the foot of *Floscularia*, and says, "Der Fuss, welcher von einer faltigen Haut bekleidet ist, endigt in zwei sehr kleinen Spitzen, zwischen denen eine etwas längere Röhre hervorragt." He gives a figure of the glands as seen in optical longitudinal section.

With regard to *Stephanoceros*: it seems on the face of

Mr. Gosse's careful observations that the source whence this secretion arises is not from a single spot, but from a considerable area. In a transverse section (Pl. I. figs. 7–9) the four pairs of muscles in the foot will be seen, each interspace being occupied by a cell possessing a nucleus and nucleolus, it being by these that the tube is secreted. The cuticle throughout the entire animal is very thin. Mr. Jackson (*loc. cit.*) says, "The body is protected by a cuticle secreted by an underlying layer of ectodermic protoplasm with scattered nuclei." It seems to me probable that these glandular cells belong to the epidermis, which in other parts of the animal is so indistinct that it is difficult to make it out even with high powers. The "leaning over" and "the moving round on the foot as a pivot" noticed by Mr. Gosse would be for two purposes—the former to solidify the case, and by pressing it down cause it to adhere to any foreign substance; the latter to keep a central space clear, so as to allow the animal sufficient room for its body when contracted. While these processes were in progress the animal would be pouring out a fresh supply, and so we should soon find it possessed of a tube of sufficient strength to afford shelter for the occupant.

Thinking it possible that the above conclusions might be verified by comparison with other species, I cut some serial sections of *Melicerta ringens.* It is well known that the young first secrete a fine tube, and afterwards build a tube of pellets round it externally. Prof. Williamson (5) says, "The animal [*Melicerta*] attaches itself by the tail to some fixed support, and develops from the skin of the posterior portion of its body a thin hyaline cylinder, the dilated extremity of which is attached to the supporting object." On examining sections through the foot I was gratified to find the mucous cells occupying the same position, though reduced one fourth in size, but resembling in every feature those in *Stephanoceros.* I think therefore one may safely assume that the tube in both instances originates from these cells.

Muscles.—This was the first point to which I directed my attention. Dr. Hudson (*loc. cit.*) says, "There are considerable differences of opinion about the muscular system. Dr. Leydig (*loc. cit.*) says that there are four muscles which rise in the foot and each of which divides into a pair as it crosses the trunk, and then subdivides into smaller branches as it passes over the coronal cup to the base of the lobes. Mr. Gosse makes them to be five pairs, and says that usually each pair runs up the trunk from the foot in a line with one of the arms, and then, before reaching it, divides into diverging branches which, at remote points, are united to a muscular collar close to the base of the arms. He notices, however, that he has seen cases where the muscles run down direct from the depressions between the lobes without uniting to form pairs. My own opinion, after prolonged observation of many specimens, is that there are really six pairs of muscles, and that they are arranged in the following fashion. Each pair runs up the foot, looking like a single muscle, and the reason why never more than four (pairs) are visible in the foot from any point of view is that there is always a pair on each side of the animal (however viewed) which is there lost to sight. At the junction of the foot and trunk each pair begins to open a little, and by the time they have reached the bottom of the coronal cup the constituents of each pair diverge obviously from each other, and terminate usually at the base of some one of the depressions between the lobes, but in such a fashion that the constituents of the same pair never end in the same depression."

According to my observations their arrangement is as follows:—On reference to figs. 7–11 (Pl. I.) four pairs of muscles will be seen placed at equal distances from one another almost immediately under the cuticle, the interspaces being occupied by the mucous cells previously mentioned. Owing to the tapering shape of the foot these muscles tend naturally to converge towards the fixed extremity; and so we find that in this latter region they come into contact, the mucous cells disappearing, the apex containing muscles only. At the junction of the foot with the body the muscles of each pair separate a little, and as they run forwards keep close under the cuticle, and never leave their own portion of the body. Anteriorly they terminate in a sphincter-muscle placed in the collar at the bases of the arms. So far as I have been able to gather from previous writers it appears to me that sufficient importance has not been attached to this muscle, styled by Mr. Gosse "circular." On examining a living specimen in a healthy condition, we find that when it retracts into the tube the bases of the arms are brought together by the contraction of this "circular" muscle, and the longitudinal muscles being almost simultaneously brought into play, a rapid retreat of the animal into its tube is the result. The presence of this muscle is also evident when the animal issues forth again, the arms being protruded as a bundle and then opened out, the setæ clothing them being immediately brought into play.

Nervous System.—Dr. Hudson (*loc. cit.*) is the only writer who has hitherto seriously raised the question whether or not that part of the Rotiferon which usually passes as the brain is really a nervous structure. He says, "What is probably the nervous ganglion is a peculiar organ consisting of large clear cells lying at the back of the vestibule near the dorsal surface. Above it and well under the dorsal surface is a three-lobed, granular, semiopaque body with which the nervous ganglion is possibly connected. The nervous ganglion in many of the Rotifera, especially among the Notommatadæ, shows a marked cellular structure at the lower end which loses itself in a granular, semiopaque, upper portion; but it must be admitted that if these peculiar bodies constitute the nervous ganglion of *Stephanoceros,* it is rather their position than their shape and structure that would lead us thus to interpret them." Mr. Cubitt (6) says, "It [the brain] is seated in the anterior region in a dorsal aspect; it is pear-shaped, constricted in the middle, where it supports certain small processes which traverse its substance as well as project beyond. In active individuals the brain is large and prominent, but less conspicuous in others, whose sluggish movements indicate disease or age; its structure is not granular, except at its internal attachment, and is in no way related to the granular layers that occur on each side of it. It presents more the appearance of a cellular structure, but differs essentially from the character of such a structure . . . the divisions incline to a pentagonal arrangement, and each junction or union of the fibres is distinguished by a definite nucleated swelling, faintly resembling Gratiolet's figures of the nerve-cells of the spinal cord." My own observations show the "brain" to be a somewhat cylindrical organ, and the walls to be composed of irregularly-shaped oval cells, each possessing a nucleus and nucleolus. Each cell is wholly or partially filled with granular protoplasm, and as the secretion present in the central space is also granular, one may fairly assume that the granules originated from the cells and that the cells were in an active state at the time of the death of the animal (*vide* Pl. II. figs. 13 and 14). The function of this organ will, I think, be easily demonstrated if we examine the living animal. Dr. Hudson (*loc. cit.*) says, "From the spot where it [the brain] adheres to the wall of the vestibule a sort of protrusile tongue or taster rises, which can be pushed forward so as nearly to fill up the interval between the knobbed ciliated ends of the ciliary wreath. This tongue may be seen incessantly pressing backwards and forwards as the food passes into the vestibule, as if discriminating between the passing atoms, just as the two tasters do in *M. ringens.*" Examination of transverse and longitudinal sections shows that the cylindrical organ previously described is open at the upper end, where it communicates with a definite single tube enclosed by thin membranous walls and narrowing towards its distal extremity, where it apparently opens into the retracted vestibule. This tube corresponds in its relations with the so-called "taster" of Dr. Hudson, and is, in my opinion, identical with it. On reference to Pl. II. fig. 14 the opening of this duct into the vestibule can be seen. Fig. 13 shows the proximal extremity of the duct with the secretion therein and its connexion with the apex of the so-called "brain." The suggestion I offer is this: the organ is of a salivary nature, the "tongue" or "taster" being a duct, its use being that as each particle of food is passed into the vestibule a minute portion of this secretion passes with it. This view seems all the more probable when we consider that salivary glands, which are present in the majority of the Rotifera, are absent in this species. Assuming this to be the case, is there any other structure to which one can point as being nervous? This, I think, can be answered in the affirmative. No observer can have failed to notice in the living animal the large, oval, nucleated cells placed close to the cuticle on either side of the collar. Dr. Hudson (*loc. cit.*) says, "oval nucleated cells are also easily seen in the wall of the coronal cup when the animal is viewed from either side." Sections taken in a plane parallel to the long axis of the animal show these to resemble in a marked degree unipolar ganglion-cells; the single process given off from each cell running anteriorly and terminating in the plumes or arms (Pl. II. fig. 1). This appears to receive further confirmation on the examination of *Melicerta ringens*. When this Rotiferon is protruding from its tube, the two paired antennæ placed ventrally, the paired recurved hooks and the rudimentary third antenna placed between them protect it dorsally, and so it is guarded on all sides. Sections show each of these to be furnished with a nerve-fibre, clearly showing their sensory nature. In *Stephanoceros*, however, we find the plumes or arms performing two functions: they act as tactile organs, and, being furnished with setæ, as food-collectors for the animal.

Eyes.—The remarks I have to make regarding these structures do not agree with those made by previous investigators. Dr. Hudson (*loc. cit.*) says, "The eyes lie on either side of the nervous ganglion; they may be seen by a dark field illumination." Mr. Cubitt (*loc. cit.*) gives the most exhaustive account. He says, "Their true character is difficult to determine; they resemble in a marked degree the eyes of Vertebrates, consisting of a globe, sending off posteriorly a fibre to the brain, and possessing anteriorly a pigment-spot, which, while favouring the form of a compound type, contains within itself a central refracting medium." He is uncertain "whether they incline to the simple or compound type; they are eminently calculated to fulfil the purposes they are required to serve, in simply conveying light, though not the perception of objects to the brain, for they possess no choroid."

I must confess that on the strength of the foregoing remarks my curiosity was considerably aroused. I examined my sections taken through the region where, in the living animal, I had seen these red bodies without finding any structure at all agreeing with a visual organ. All that I could find were two spherical bodies, one being placed more superficially than the other, of a chitinous nature, and which, when examined with a dark-ground illumination, resembled in every way the so-called eye. The firmer and more external one is imbedded in a homogeneous structureless mass, which presents at some points certain lines of no definite outline (*vide* Pl. II. fig. 6). The organ appears to be composed of two parts, an outer ring of a highly refractive nature, enclosing a central opaque mass. The second eye is placed deeper in the tissues of the animal, and the homogeneous mass in which it is placed does not appear to possess the firmness noticed in its fellow. The organ is composed of a less dense material, splinters readily under the knife, and shows in consequence its structure admirably. These organs are not present in all my sections. As to their use to the animal I am unable to offer at present any suggestion; but I think one may safely assume they are not visual organs.

Ovary and Development.—The remarks I have to make under this heading are few, but still of considerable interest. The earliest writer, so far as I can find, who has touched upon the origin of the envelope surrounding the ovum is Prof. Huxley. He says (7), "The ova are developed thus:—One of the vesicles increases in size, and reddish elementary granules appear in the homogeneous substance round it. This accumulation increases until the ovum stands out from the surface of the ovary; but invested by its membrane which, as the ovum becomes pinched off as it were, takes the place of a vitellary membrane."

Dr. Zacharias (*loc. cit.*) says, "The process of separation is so effected that a portion of the enveloping membrane of the ovary is separated with it and transferred to the ovum, so that the embryo in its development lies in a completely closed hyaline vesicle, which, from its origin and function, is to be regarded as a real uterus." With these remarks my investigations entirely agree; but, as both the above-mentioned authors obtained their views by means of optical sections, I have thought it desirable to give a figure of it in section, so have placed fig. 18 among my illustrations.

Dr. Hudson (*loc. cit.*) says, "In *Stephanoceros* (as in a few other Rotifera) the young (as Ehrenberg conjectured) is occasionally born alive." In all my serial sections of this Rotifer embryos are found in section in the body-cavity in various stages of development. In the case of some they are in a most advanced condition; the trophi are to all appearance fully formed and in a fit state to allow the Rotiferon to lead a separate existence. They do not appear to occupy any definite space in the body-cavity, being, as stated by Dr. Zacharias (*loc. cit.*), "thrust hither and thither by the movements of the animal." At the same time, however, the fact must not be passed over in silence that the Rotiferon, besides possessing embryos in the body-cavity, also possesses ova within the tube. Unfortunately I have not been successful enough to obtain these latter in section, owing to the tube invariably dissolving during the various treatments the animal has to pass through before it is ready for the microtome. The ovum being simply placed within the cavity of the tube, and not attached to anything, is easily lost.

I have not as yet been fortunate enough to witness the birth of the embryos; bearing in mind their large size and the comparative smallness of the cloacal opening, it seems to me most probable that the parents die, and by their death liberate the enclosed embryos. Quite recently I have on two occasions found in my small aquarium partially decayed specimens, with two, and in some instances three, embryos within the tube, and swimming therein apparently in a healthy condition. These embryos may, however, have been hatched from those eggs within the tube; but in one instance there were within the tube two unhatched eggs which also contained free embryos.

In one series of sections I found an ovum that had formed a gastrula by epibole (Pl. II. fig. 17). Dr. Zacharias has viewed this in *Rotifer vulgaris*, but has given no figure of it. The figure I have given was obtained in section of a specimen, so will confirm his remarks. Unfortunately I have been unable to secure any more specimens containing embryos exhibiting the early segmenting stages; but from those I possess more advanced I am inclined to imagine that after segmentation histolysis sets in and rapidly obliterates the previously existing cells.

Body-cavity.—Mr. Jackson (*loc. cit.*) says, "the cœlome does not extend into it" [the foot]. On reference to figs. 7 and 8 it will be noticed that, owing to the mucous cells failing to meet in the centre, a considerable space exists in this region of the foot. As to whether or not this space is caused by the reagents used I am unable definitely to determine; anyhow, it is present in all my sections, and is also plainly visible in the same region in *Melicerta ringens.* Owing to the tapering shape of the foot this space gradually decreases in size as one passes to the attached extremity; it terminates at the junction of the four pairs of muscles. Anteriorly it continues into the trunk, and thence into the arms, there being, so far as I can discover, no septum dividing them. At first I was inclined to imagine that the reagent used as a stain had failed to affect the protoplasm of the arms; but, on further examination, I found that the arms simply consisted of a delicate cuticle, a continuation from the foot and trunk. Lining this integument is a denser substance, not exhibiting any definite cell-structure. From its greater density I should infer this substance to be a skeletal tissue.

Zoologists seem fairly agreed that there is a fluid within the body of the animal; but as to whether or not the "vibratile tags" with their canals are of the nature of a vascular or excretory system opinions seem fairly divided. When commencing my study of this Rotifer I hoped to obtain some interesting results with regard to these structures; but so far I have failed to find any trace of them in sections. Owing to the hollow nature of the arms one can easily imagine that the animal protrudes from its case by the fluid occupying the body-cavity being forced forward.

Parasites.—In one of my earliest series of sections of this Rotifer I met with a structure in the region of the posterior third of the body which for a considerable time I was unable to explain. It consists of an ovoid body placed directly under the cuticle and sharply divided from the rest of the Rotiferon by a well-defined membrane. Scattered irregularly within this body are numerous cells, varying considerably in size, and placed excentrically is a large ovoid capsule, bounded by a wall of apparently a chitinous nature, a small opening being visible at the point nearest the cuticle. Lining the interior of this capsule is a thin layer of homogeneous protoplasm, from which extends a delicate fringe of cilia which completely fill the cavity (Pl. II. fig. 16). Shortly after I met with Dr. Zacharias's paper, and at once recognized my specimen as a species of *Trypanococcus*, discovered by Prof. von Stein many years ago. In a footnote Dr. Zacharias (*loc. cit.*) says, "On careful examination of fig. 1 (*Stephanoceros Eichhornii*) on the first of the four plates which Prof. Leydig has appended to his fine memoir on the structure and systematic position of the Rotatoria, I see a structure, marked with the letter *h* (on the right at the fore part of the animal), of which the distinguished histologist confesses that its significance was unknown to him. He describes it as 'a group of limpid vesicles which open on the cuticle by a duct, which, although short, is distinct in a suitable position.' Have we not here a similar observation to that which I have frequently made in *Rotifer*?"

There are two points in which this specimen does not agree with the above description. There is no visible duct to the exterior. It is a single vesicle only. I may also remark that I have cut many serial sections of this Rotifer and have only found the parasite present in one instance.

I am now engaged in examining *Melicerta ringens* by means of serial sections, and I hope before long to offer some remarks on that species.

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(5) WILLIAMSON, W. C. "On the Anatomy of *Melicerta ringens*," Quart. Journ. Micr. Sci. vol. i. 1853.

(6) CUBITT, C. "Observations on some Points in the Economy of *Stephanoceros*," Monthly Micr. Journ. vol. iii. 1870.

(7) HUXLEY, T. H. "*Lacinularia socialis*: a Contribution to the Anatomy and Physiology of the Rotifera," Trans. Micr. Soc. Lond. vol. i. 1853.

EXPLANATION OF THE PLATES.

PLATE I.

Fig. 1. Section parallel to the long axis of *Stephanoceros*. *a*, unipolar ganglion-cell placed at the base of an arm with single nerve-fibre; B, space in arm (body-cavity); *c*, cuticle; *pe*, setæ; *m*, muscles. Zeiss F, oc. 3.

Fig. 2. A group of unipolar ganglion-cells, showing each ganglion-cell with its single nerve-fibre. Zeiss F, oc. 3.

Fig. 3. Transverse section of Rotiferon. *m*, vestibule; *c*, taster or tongue; *b*, "brain;" *e*, embryos in section; D, calcareous granules; *f*, cuticle. Zeiss C, oc. 3.

Fig. 4. Transverse section of Rotiferon. *a*, external eye; *b*, the deeper eye; *c*, calcareous concretions; D, commencement of mastax; *e*, cuticle. Zeiss C, oc. 3.

Fig. 5. Portion of fig. 3. *a*, deeper eye in median transverse section; *b*, portion splintered off; *c*, external eye; *f*, cuticle. Zeiss F, oc. 3.
Fig. 6. Portion of fig. 4. *a*, fragments of deeper eye; *b*, external eye; *cu*, cuticle. Zeiss F, oc. 3.
Fig. 7. Transverse section of foot immediately beneath the junction with the body. *m*, the four pairs of longitudinal muscles; *m. c.*, mucous cells; *cu*, cuticle. Zeiss F, oc. 3.
Fig. 8. Transverse section of foot three sections lower, showing considerable decrease in size. The lettering as in previous figure. Zeiss F, oc. 3.
Fig. 9. Fifth section of foot. The animal invariably dies with this region of the foot twisted. Zeiss F, oc. 3.
Fig. 10. Seventh section of foot. Zeiss F, oc. 3.
Fig. 11. Extremity of foot. *a*, the cup-like extremity; *b*, union of muscles. Zeiss F, oc. 3.
Fig. 12. Portion of cuticle under high power. *a*, cellular layer; *b* and *c*, granular. Zeiss K, oc. 3.

PLATE II.

Fig. 13. Almost vertical section of Rotiferon. *b*, "brain;" *s*, secretion; *m*, vestibule; *e*, embryo; *ov*, ovary; *cu*, cuticle. Zeiss E, oc. 3.
Fig. 14. Three sections later, showing the connexion between the lumen in the "brain" and the vestibule. Lettering as in previous figure. Zeiss E, oc. 3.
Fig. 15. Median transverse section of "brain." *cu*, cuticle. The secretion in central lumen is not figured. Zeiss F, oc. 3.
Fig. 16. Median transverse section of *Trypanococcus*. *cu*, cuticle of Rotiferon; *a*, cyst containing cilia; *b*, its opening. Zeiss F, oc. 3.
Fig. 17. Formation of gastrula by epibole. Zeiss F, oc. 3.
Fig. 18. Transverse section of ovary. *ov*, ovary; *a*, an ovum; *b*, membrane of ovary being detached with ovum and forming the vitelline membrane. Zeiss F, oc. 3.

II.—*Report upon the Hydrozoa and Polyzoa collected by P. W. Bassett-Smith, Esq., Surgeon R.N., during the Survey of the Tizard and Macclesfield Banks, in the China Sea, by H.M.S. 'Rambler,' Commander W. U. Moore.* By R. KIRKPATRICK.

[Plates III.–V.]

COLLECTIONS of the marine faunas of Tizard and Macclesfield Banks were made by Mr. P. W. Bassett-Smith, and were presented to the British Museum (Natural History) by the Lords of the Admiralty. A list of the Hydrozoa and Polyzoa obtained, with descriptions of new species, is given below.

HYDROZOA.

The collection of Hydrozoa from the Tizard and Maccles-